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solplan review

the independent newsletter of energy conservation, building science & construction practice

Inside. . . .

The incremental cost of construction innovations is always of interest. One of the features studied by the Flair Ener Demo project in Winnipeg was just what was the cost impact of alternate ways to upgrade to the R2000 home standard.

Draft proofing is one of the fundamental aspects to upgrading construction. Polyethylene and airtight drywall approaches are the two common directions for attaining necessary tightness. The results of the Flair Enerdemo project suggest a hybrid approach that is presented in this issue.

Is the true thermal resistance of an assembly really what we calculate it to be? Several arctic houses were tested and in most cases actually found to be better. Preserved wood foundations are common but have not been monitored. We report the results of a survey to determine just how they work in the field.

HOT2000 was originally developed for the R2000 program. It has undergone continuous revisions. We present a review of version 5.06, the latest upgraded release.

Gas fireplaces are becoming common. Unfortunately, some models can be a hazard. We report on what the problem is.

Other items include a report on a new window spacer; Manitoba radon program; recent findings about how radon performs, developments in energy efficient home appliances, and tests on kitchen fan performance.

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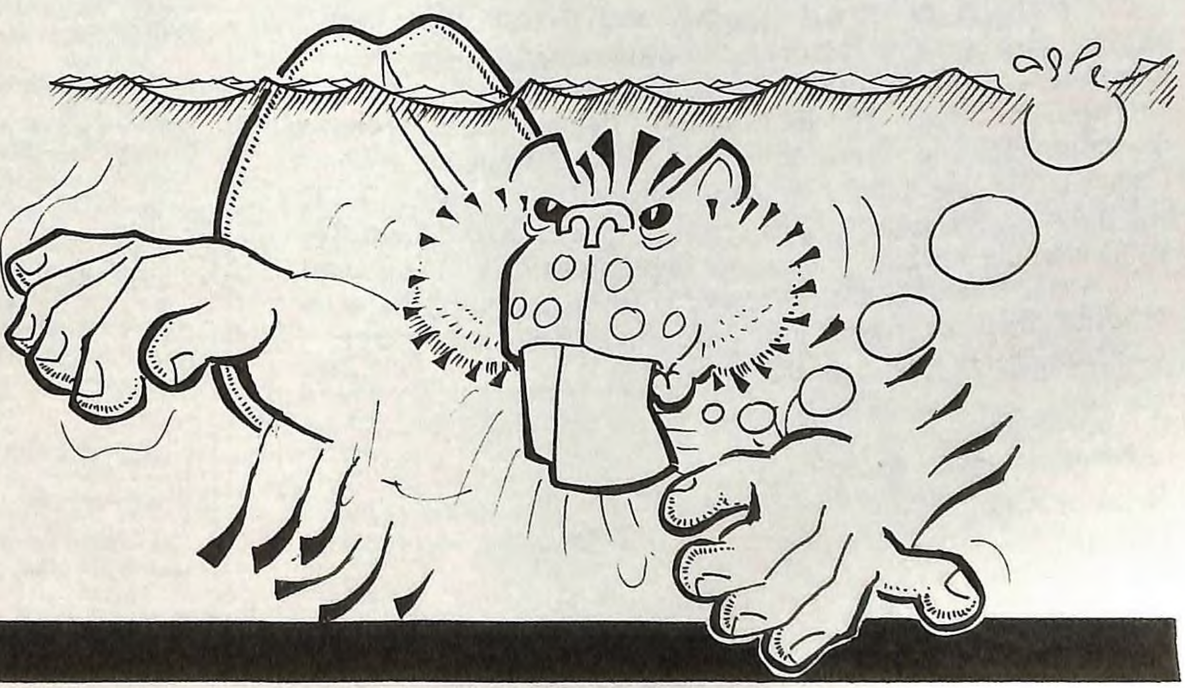
Easy Airtightness



From the Publisher

Homebuilders are a fun loving bunch of guys who enjoy a good party. But then who doesn't?

When a builder's association spends as much effort being a social organizer as it does being a professional body serving the technical and business needs of professional builders, what does that tell us? Do you join a professional association for the good parties they organize, or to deal with important business and technical issues?

What brings up this party talk are the results of a member questionnaire at one of the larger CHBA locals. A majority of members responded, so it must be assumed that the results are a fair representation of member opinions. And just what did they have to say? Looking at a summary of the results the impression is that social activities were of major importance. Judging from the programs and attendance at provincial and national conventions, the results are not unique to this local.

Entertainment (speakers/content) rated highly for general meetings, while technical trailed the list. Recommendations for new events and program improvements stressed social activities, from another golf tournament, to picnics, to strippers and gambling tables at the 'gent's' night.

To be fair, there also was much interest in political issues, especially the important matter of dealing with local regulatory authorities that causes so much daily aggravation.

On how best to motivate recruitment of new members, most needed incentives, from cash to free dinners (only 16% said no incentive was needed). A professional association that is seen to meet member needs should not need to bribe its members and prospective members to recruit newcomers.

The building industry is very fragmented, with many players, but it is also a major factor in the economy. As such, the industry has to deal with many significant technical, regulatory, and political issues. The industry must deal with new technical developments and innovations head on in a proactive manner ("what is the best means we can improve the way we ..."). At the moment the industry just tends to react ("how do we stop ... from introducing new mandatory regulations on ...").

If social concerns are the major concerns, then perhaps the industry deserves what it gets from the public (poor image, questionable regulations, etc).

R. Kadulski
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Incremental Costs of Energy Conservation

Since the energy crisis of the 1970's the Canadian housing industry has improved standards for energy conservation and developed many design options for new construction.

Innovation has created new problems. Until recently a builder had few choices designing and building the non-architectural components of a house (such as the wall system, insulation, types of heating, windows). Today there are many alternatives for each component; some are more cost-effective than others, others are technically better.

Choice means more flexibility in design and a better ability to tailor the house to the marketplace. On the down side more decisions must be made at the design phase and workers must learn and apply new construction techniques on the job site. As it takes time for workers to learn to incorporate new construction techniques, *change* in itself is an added cost.

For the builder, the objective is to select options that maximize performance while minimizing the extra cost. One way to do this is to get cost estimates for a variety of options and analyze their performance using a computer program such as HOT-2000. Unfortunately, few builders have time or inclination for such an exercise.

The optimum energy conservation package will vary due to energy cost, climate, type of house, consumer acceptance and most importantly, the builder's ability to market an energy-conserving house. The key to optimizing a design is to create a balance between each component's heat loss and the cost of reducing this loss. Designs too often over-emphasize some components while ignoring the others.

The Cost of Learning

The time to learn a new system will vary with its complexity, worker experience and the how big the change is from conventional practice.

Experienced framers estimate that the first time a new technique is used it will take 25 to 35% longer to frame that house. The incremental time decreases to 10 to 20% when it is used in a second house, and nears zero for the third and subsequent houses.

Thus, if a new system takes an additional 10 hours conventional practice, the first house using the approach would take an additional 12½ to 13½ hours, while the second house would take 11 to 12 hours extra.

Change disrupts the normal process of building a house. Direct and overhead costs can increase if rescheduling of subtrades or material orders are changed.

For larger tract builder, the cost of change increases because of added costs in a larger corporate bureaucracy, such a communication from the office to area manager to site supervisor to relevant trades. For a smaller custom builder it is easier, as a single individual is likely to be doing all these jobs. Because of these costs, efficient builders producing the best product for the least cost try to minimize variations from house to house. Once a "package" has been designed, it is best to keep alternatives to a minimum. Changes must thus be considered carefully.

Cost Study Approach

The $1 million Flair Homes Energy Demo project, funded by Energy, Mines and Resources Canada and Manitoba Energy & Mines, involved 20 almost identical bungalows built in 1985 and 1986. The study looked at the performance of various wall systems and ventilation/heat recovery systems. The monitoring was done over three years by UNIES Ltd., Winnipeg consulting engineers with extensive experience in residential construction.

The project looked at the cost effectiveness of options commonly used to improve the energy efficiency of a house. How much insulation to install will depend on location, climate, local market conditions and cost of fuel. However, the project findings do suggest the order in which upgrades can be made cost-effectively.

Cost estimates were developed using a conventional 1040 sq.ft. (97 m^2) bungalow with a full basement as the reference. The builder was assumed to be a tract builder experienced in energy efficient construction. Incremental costs were defined as direct costs which the builder would incur beyond those normally encountered using conventional practices. Overhead, profit or learning time were not taken into account. A review of other recent studies that looked at the incremental cost of energy conservation measures was made. They offered some insights in the development of this project.

The wide variations in the reported incremental costs of various systems suggested that builder experience with the systems was a major factor in their cost estimates. One 1983 study looking at the cost effectiveness of R-2000 homes asked builders to estimate the cost to upgrade envelope airtightness for a standard house. Builders responded with a range of $150 to $1050 for a simple bungalow and $0 to $2075 for a 2 storey design. This implies that builders may have been more influenced by their own experience with an approach than its actual cost. Experience has an impact on costs. Thus to provide a fair comparison, this study assumed a common experience level.

Assessing incremental costs is not as easy as measuring energy consumption. A construction site is a dynamic environment, unlike a factory or laboratory, so assessing the cost of a small design change is not easy. Labour costs are more difficult to establish accurately if the changes involve more than one subtrade.

Builders appear to have different opinions as to what constitutes overhead. Administration, taxes, rent,

profit, supervision, insurance, interest charges, learning costs, etc. are all possible components.

Most houses, including those built by R-2000 builders, are not always optimized with respect to the R-2000 energy target or other energy standards. Thus by reporting total package costs rather than component costs one may include unnecessary expenses due to "over-design".

The perfect cost study that incorporates all real costs will never exist. Cost differences caused by variations in house design, material and labour charges, inflation, quality of construction, size of business, experience, and market preferences make any study incomplete and quickly out of date.

Costs were developed on a "system" basis with a system defined as a single conservation measure applicable to one part of the house. Typical systems included: an upgraded wall, underslab insulation and a high efficiency heating system. Each was analyzed by breaking it into component steps which described the additional or deleted material and labour requirements relative to a conventional house.

Cost Performance Index

A Cost Performance Index (CPI) was developed for this study. It describes the cost effectiveness of upgraded insulation systems; the larger the CPI, the greater the cost effectiveness. It is not applicable to airtightness or mechanical systems.

For example, a wall system which used 2x6 framing with 1" rigid exterior insulated sheathing required: additional studs, corner bracing, insulated sheathing, tape and longer fasteners. However, the system eliminated the need for conventional fibreboard sheathing and building paper.

Subtrades often bid on a task basis without breaking down between labour and materials and no disclosure of hourly rates. In these cases, estimates were made of the effective, average labour rates for the various subtrades.

Material costs used supplier prices with allowances for waste. Costs were provided by Flair Homes' normal suppliers as of the spring of 1987.

TABLE 1

MATERIAL COSTS

2"x 6" #2 or better Kiln-dried spruce	$328.00/1000 bd ft
5/8" fibreboard sheathing	$0.246/ft^2 ($2.84/m^2)
Batt insulation	$0.02/ft^{2}R ($1.22/m^{2}RSI
2" Glasclad insulated sheathing c/w Tyvek a b	$0.698/ft^2 ($7.51/m^2)
2" Styrofoam (SM) insulated sheathing	$0.863/ft^2 ($9.29/m^2)
6 mil polyethylene	$0.0245/ft^2 ($0.264/m^2)
Acoustical sealant (900 ml tube)	$4.98/tube

LABOUR RATES

Framers	$15.00/hour
Drywallers/Insulators	$12.00/hour
Painters	$15.00/hour
Electricians	$17.50/hour
Sheet Metal Installers	$15.00/hour

(1987 Winnipeg supplier prices)

Sample material prices are shown in Table 1.

Practical Energy Conservation Upgrades

The most important aspect of designing an energy conservation package is balancing the design so that the extra cost for the package produces the maximum energy savings.

The first step in considering changes or upgrades is to review the distribution of heat losses from a house as this provides a rough indication of where upgrade efforts should be directed. For a typical bungalow with full basement the distribution of annual space heating losses would be approximately:

Walls	10% to 20%
Ceiling	10% to 15%
Basement Walls	10% to 15%
Slab	10% to 15%
Windows	10% to 25%
Doors	2% to 5%
Air Leakage	20% to 35%

WALLS

For many builders, the exterior walls are the main focus of attention when designing an energy-conserving house. The most cost-effective upgrade for wall systems is to switch from 2x4 to 2x6 single stud frame construction. It is economical and easy to implement. Beyond a 2x6 wall the most cost effective measure is to add interior strapping/insulation or exterior insulated sheathing. Thicker stud walls are not recommended because the thermal bridging effects become too significant.

To maximize the cost effectiveness of walls with exterior insulation sheathing, the conventional structural sheathing has to be replaced by the insulated sheathing and structural bracing.

Jamb extensions are the main component of the incremental cost. If jamb extensions are used with exterior insulated sheathing for maximum cost effectiveness thinner sheathing (1") should be used.

Double walls can be used where energy rates are very high or the climate is severe but only after other envelope components and mechanical systems have been considered.

ATTICS AND ROOFS

Often heavily insulated, most attics can be economically upgraded because the additional cost of insulation and labour is small. Vaulted ceilings are an exception because the rafter depth must be increased.

However, it is important to ensure that the ceiling is as airtight as possible

TABLE A

SYSTEM COMPONENTS	NOMINAL R-value	CONVENTIONAL (2x4) IC/Sqft	CPI	CONVENTIONAL (2x6) IC/Sqft	CPI
WALLS					
2x6 @24" with 5/8" fibreboard	20.0	$0.37	47		
2x6 @16" with 1" ext Glasclad, taped Tyvek a.b.	24.4	0.78	29	$0.44	11
2x6 @16" with 1½" ext Glasclad, taped Tyvek a.b.	26.7	1.08	22	0.74	9
2x6 @16" with 2" ext Glasclad, taped Tyvek a.b.	28.8	1.29	20	0.95	8
2x6 @16" with 1" ext Glasclad, Tyvek a.b. (reversed joints not taped)	24.4	0.72	31	0.38	13
2x4 @16" with 1½" ext Styrofoam sheathing insul	19.5	0.78	22	0.44	-2
2x4 @16" with 2" ext Styrofoam sheathing insul	22.0	0.99	20	0.64	4
2x4 @24" with 1½" ext Styrofoam sheathing insul	19.5	0.69	25	0.35	-2
2x4 @24" with 2" ext Styrofoam sheathing insul	22.0	0.90	22	0.55	4
2x6 @16" with 1½" ext Styrofoam sheathing insul	27.5	1.13	22	0.79	9
2x6 @16" with 2" ext Styrofoam sheathing insul	30.0	1.39	19	1.04	8
2x6 @24" with 1½" ext Styrofoam sheathing insul	27.5	0.99	25	0.65	11
2x6 @24" with 2" ext Styrofoam sheathing insul	30.0	1.25	21	0.91	10
Double wall	40.0	3.58	9	3.21	4
BASEMENT WALLS					
2x3 strapping, R12 fiberglass batts	12.0	$0.04	219		
2x3 strapping, R20 fiberglass batts	20.0	0.21	124		
2x3 strapping, R24 fiberglass batts	24.0	0.32	97		
2" exterior Baseclad, interior unfinished	8.5	0.83	-11		
3" exterior Baseclad, interior unfinished	13.5	1.20	11		
2" exterior Styrofoam, interior unfinished	10.0	0.95	0		
3" exterior Styrofoam, interior unfinished	15.0	1.44	12		
2" exterior Baseclad, R10 interior fiberglass batts	18.5	1.30	19		
2" exterior Styrofoam, R10 interior fiberglass batts	20.0	1.41	19		
1" Glasclad under basement floor slab	5.5	$0.44	881		
1" Styroofoam under basement floor slab	6.0	0.52	762		
CEILING					
R45 blown-in cellulose	45.0	$0.07	22		
R50 blown-in cellulose	50.0	0.13	20		
R55 blown-in cellulose	55.0	0.20	18		
R45 blown-in fiberglass	45.0	0.08	19		
R50 blown-in fiberglass	50.0	0.16	17		
R55 blown-in fiberglass	55.0	0.24	15		

IC/Sqft: *Incremental cost per square foot area for the upgrade, over the base case*
CPI: *Cost Performance Index*
Baseclad: *rigid fiberglass insulation for below grade applications (Fiberglas Canada Inc.)*
Glasclad: *rigid fiberglass insulation with Tyvek air barrier factory applied, for above grade applications*
Styrofoam: *SM type, rigid polystyrene foam insulation by DOW Chemical Co.*

to prevent air leakage and subsequent moisture damage.

BASEMENTS

The basement is often inadequately insulated, as it is often mistakenly thought that the surrounding soil is a good insulator. (This may be the case but only if it is dry). Interior wall insulation systems consisting of framing and insulation are easy to install and very cost effective. Exterior insulation systems are less cost effective but can reduce water movement into the basement. The floor slab is often ignored even though it is responsible for a major portion of the total loss.

For basement systems use high levels of interior basement wall insulation; R-20 would be appropriate for most Canadian and northern U.S. applications.

Exterior basement wall insulation should be used where there are concerns about moisture transport into the foundation or if frost penetration to the footing level is possible.

WINDOWS

Developments in window technology have made it increasingly hard to evaluate new products. The R value is often considered as the main indicator, but this can give a misleading indication if the conditions under which it is used are not understood. The R-Value of the entire window (including frame) is important - not just the centre of the glass (which is the most common rating used).

To maximize passive solar gains, use windows with high shading co-efficient values.

DOORS

Doors represent a small portion of a house's total heating load. Probably the most important factor of door selection is the durability of the weatherstripping as premature deterioration will cause air leakage.

Practical and Painless Energy Conservation

EAT or Easy Air Tightening

Designing and building a draft free house does not have to be an expensive or difficult process. The system suggested here can be called **Easy AirTightness** or **EAT**. It consists of three main elements:

1. Concentrate on the major sources of air leakage
2. Use a combination of the poly approach and the Airtight Drywall Approach (ADA) to seal leakage sources.
3. Check each house using a leak detector to verify that none of the major areas have been left unsealed.

Major sources of air leakage

The best method of achieving a draft free house is to concentrate on the major sources of air leakage. These typically are:

- *Headers*
- *Cantilevers*
- *Partition wall/ceiling interfaces*
- *Partition wall/main wall interfaces*
- *Wall/floor/roof intersections*
- *Windows and doors*
- *Fireplaces*
- *Naturally aspirated furnace vents*
- *Electrical outlets*

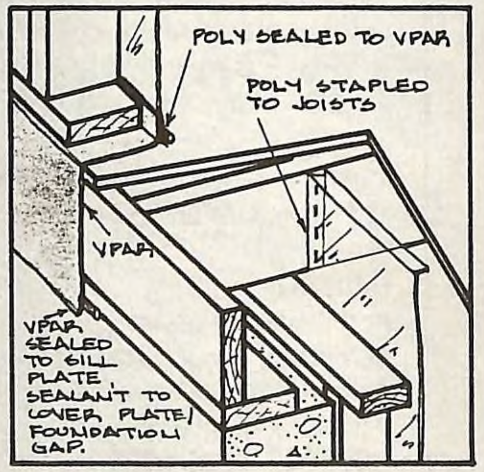
Air barrier systems

The two most common types of air barrier systems are the poly approach and the Airtight Drywall Approach. The former uses sheet polyethylene for the air and vapour barriers while the latter uses drywall and gaskets to form the air barrier with paint (or polyethylene) as the vapour barrier. Each system is usually promoted as the only acceptable technique. In fact, both systems have strengths and weakness.

Easy AirTightness (EAT) uses a combination of the two techniques. Both polyethylene and gaskets are used to form air barriers with poly used as the vapour barrier. In addition, another class of materials, vapour Permeable Air Retarders (VPAR's) are used to handle difficult areas. A VPAR is a material (such as **Tyvek**) that retards the flow of air but is (relatively) permeable to water vapour. As a result, a VPAR can be placed on the warm side, cold side or at any point through an insulated assembly. Preferred methods for sealing the major areas are discussed below.

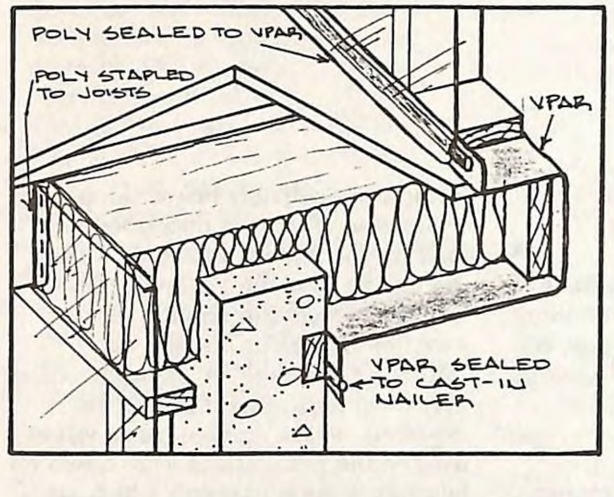
Headers

The preferred Technique is to route a VPAR strip from the bottom of the sill plate or header to the warm-side face of the bottom plate. Seal at the header and to the main wall poly air/vapour barrier.



Cantilevers

Route a strip of VPAR around the header and the underside of the cantilever and seal to the sill plate or a cast-in-place nailer. If the cantilever is particularly long, add rigid insulated sheathing underneath the cantilever to raise the floor surface temperature.

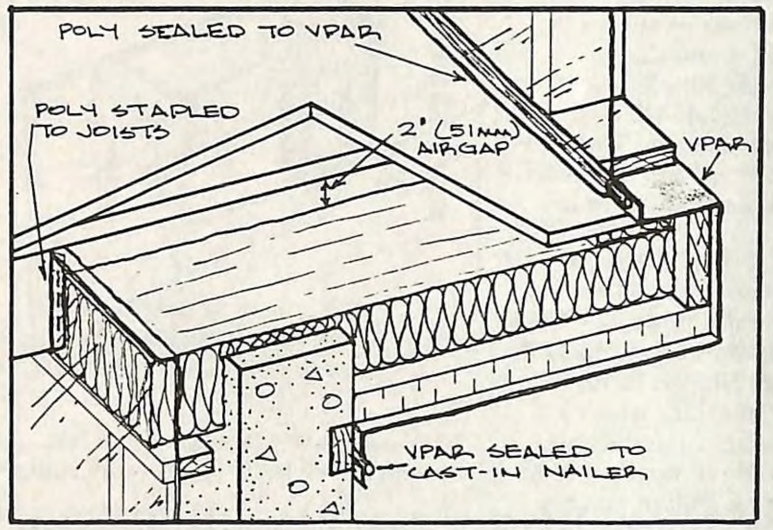


Avoid running heating ducts through the joists into the cantilever they may leak heated air into the joist space and the presence of the duct means lower insulation thicknesses.

Wall/Floor/Roof Intersections

Route a piece of VPAR around the header to the knee wall bottom plate, sealing it to the main wall and knee wall bottom plate, sealing it to the main wall and knee wall poly air barriers. A poly vapour barrier is stapled to the underside of the floor and between each joist.

If architecturally appropriate, bring the triangular space (normally behind the kneewall) into the heated envelope and route a poly air barrier along the underside of the roof rafters.



Partition Wall/Ceiling Interfaces

Install the ceiling air barrier prior to the partition walls. Rescheduling of the drywallers, framers, plumbers and electricians may be required.

If some of the partition walls are load-bearing and must be installed prior to the roof framing, seal the poly ceiling air barrier to the top plates of the partition walls. If the quality of the wood used for the top plates is good (no splits or knots through which air can leak), the poly strip between the two plates can be omitted.

Fireplaces

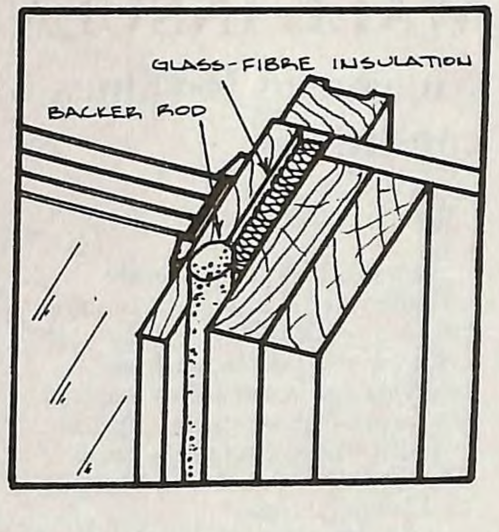
Select fireplaces which have well-sealed doors with high quality weatherstripping. One or two panel doors are preferable to accordion types which are difficult to seal.

Vents

The preferred technique for furnace vents is to use an induced draft or condensing furnace which does not require an open vent or use an electric heating system. Naturally aspirated furnaces are a potential hazard due to back-drafting and their lower seasonal efficiency makes them inappropriate for energy-efficient construction.

Windows and Doors

Use fixed windows where appropriate, otherwise use casement or awning units since these place the weatherstripping in compression and achieve a tighter seal than sliding units.



Seal the gap between the rough opening and the frame with backer rod. Scraps of glass fibre insulation can be jammed into the gap to reduce heat loss. As the gap will vary with different installations, it will be necessary to keep three or four different sizes of backer rod on site.

Electrical Outlets

Electrical outlets on exterior walls and the ceiling should be kept to a minimum; locate them on the interior partitions whenever possible. Outlets which cannot be relocated must use rigid poly pans, face-plate gasketed electrical covers, site-manufactured VPAR boxes or airtight electric boxes.

Avoid recessed fixtures which extend into the attic space.

In the Flair project when these steps were followed and the house still failed the airtightness test, it was usually because one or two major of the leakage areas were forgotten or poorly constructed.

Preferably, every house should be checked for leakage.

This item has been adapted from the "Flair Homes Project REPORT NO. 2, Incremental Costs of Energy Conservation" prepared by Gary Proskiw of Unies Ltd. and "Practical and Painless Energy Conservation" a paper presented by Gary Proskiw at the EBBA Conference in Winnipeg, March 1989.

WALL INSULATION

Measured R-values in arctic conditions

Heat loss from houses in the Canadian Arctic is a major concern. Fuel oil, which is used to heat most houses in the remote northern communities, is costly thus the need for houses that are energy efficient and able to stand up to the harsh climatic conditions of long winters and cold temperatures.

It has been suggested that the harsh climate creates a unique environment that over time may reduce the insulating value of wall sections. Factors such as shrinkage of wood shifting of structures and degradation of individual components within wall sections may create air spaces between the insulation and the studs, allowing for convective loops to form. Degradation of individual building components may be caused by moisture migration into the structure.

Building officials in the Northwest Territories Housing Corporation and Yukon Housing Corporation are concerned about the long term performance of building components exposed to the Arctic environment.

To see if there is any cause for concern, a field study was done by G. K. Yuill and Associates for CMHC. It looked at the wall sections in several Arctic houses to see if there is accelerated deterioration causing reduction of insulating value, and what the reasons might be for the deterioration.

Four houses were selected for detailed testing. Each was to have been a different type and constructed in different years to see if wall sections in older houses show signs of increased deterioration. Because many older houses (built before 1980) have deteriorated wall sections, the houses selected were either constructed or retrofitted within the last five years.

Testing was done in two steps. The first was to take infrared thermography scans on the wall sections chosen. The second was to measure the heat loss through the wall sections using guarded hot box calorimeters.

Temperature measurements made included indoor temperature, outdoor temperature, air film temperatures on the outside of the exterior wall section (over-stud and non-stud). In the analysis to determine thermal resistance values (R-values) two temperatures were used: the average indoor air film temperature and the average outdoor air film temperature.

The effective R values measured in the four housing units are more meaningful when they are compared to their theoretical values (listed in Table 1). Theoretical values were calculated using the cross-sections as shown in Figures 1, 2, 3, and 4 and the individual component R-values obtained from the ASHRAE Handbook of Fundamentals. Thermal bridges (including wood framing and strapping) were accounted for in the calculations.

As indicated in Table 1, the measured R-values of the wall sections tested are, in general, reasonably close to their theoretical values (within 15% of their theoretical values). In three cases, the measured values were actually higher than the theoretical values. There are three major reasons for this. First, the baseboard heaters, located immediately below the test equipment may have decreased the load on the heating elements within the test equipment. Secondly, there was likely a certain amount of experimental error. Finally, the insulating materials in the wall sections may have performed better than expected, as the component R values used in the calculations were based on laboratory measurements which are made at about 24°C. As temperatures decrease, the insulating value of materials generally increases.

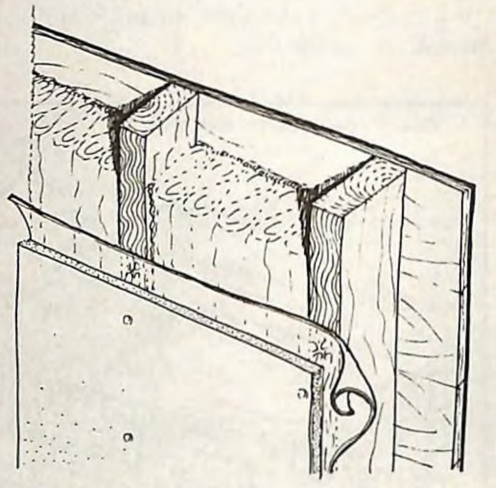


Fig. 1
½" gypsum board; poly v.b.; R20 batt insulation; 2x6 studs @24"; cedar siding

TABLE 1

House No.	House Type	Construction Year	Measured R-Value *(RSI)*	Calculated Difference *(RSI)*	Percentage Difference*
1	Nineplex	1984	20.78 *(3.66)*	18.34 *(3.23)*	-13.3%
2	Duplex	1985	28.90 *(5.09)*	25.55 *(4.50)*	-13.1%
3	Retrofit (1976 Single Detached)	1986	11.98 *(2.11)*	20.61 *(3.63)*	41.9%
4	Duplex	1986	30.43 *(5.36)*	27.08 *(4.77)*	-12.4%

** Calculated R value relative to actual measured numbers*

The measured effective R-value of the wall section in House No. 3 was found to be 42% lower than the calculated theoretical value. The infrared thermography scan did not indicate signs of moisture damage. However, there was an air space behind the gypsum board wall to which the test equipment was attached. Cold spots that were close but not immediately behind the metered area may have provided a route for heat to escape from the adjoining air space by convection currents in the void.

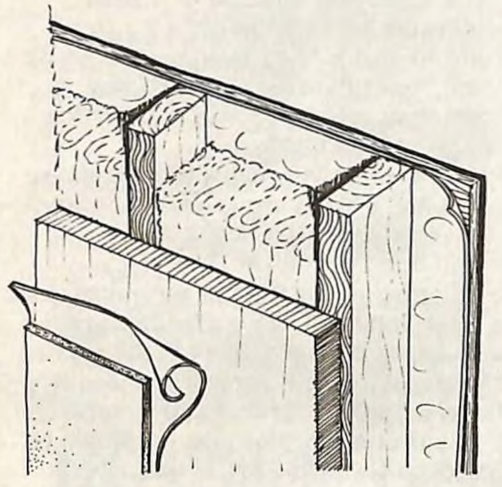


Fig. 2
½" gypsum board; poly v.b.; 1" rigid insulation; R20 batt insulation; 2x6@24"; air barreir; 5/8" plywood siding

So what did the exercise prove?

The results show that major reductions of insulating value of wall sections in houses constructed in the last five years have not happened as the measured R-values appear to be in line with theoretical calculations.

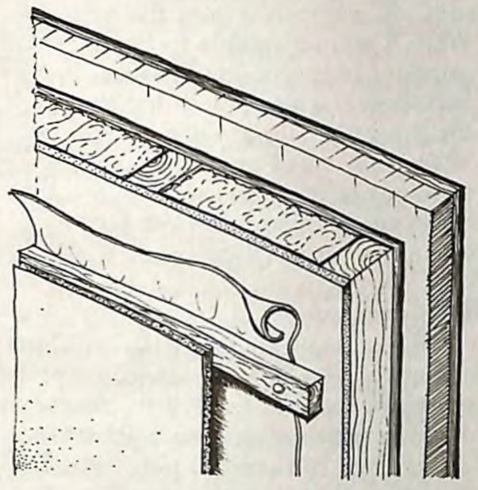


Fig. 3
gypsum board on 1x3@ 16"; 6 mil poly v.b. on existing wall plus 2x2 vertical @4'0" with 1½" glasclad and plywood siding

The oldest house tested was built in 1976 and retrofitted in 1986. It was the only house where the insulating value tested was lower than the theoretical value. What the cause for this reduction of R-value were not identified in this project. However, as there was an air space in the well, it may be the convection currents were established in the cavity and worked to spead heat transmission through the wall.

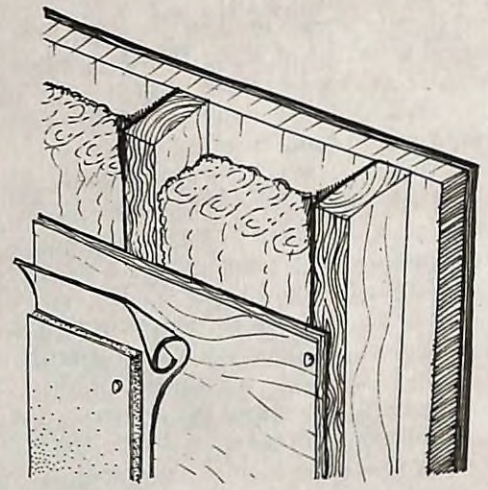


Fig 4
½" gypsum board; 6 mil poly v.b.; 3/8" plywood; R20 batt insulation; 2x6@24"; 1½" glasclad; plywood siding

Summary of: "In situ testing of the thermal performance of wall sections in NWT" by G.K. Yuill & Assoc. for CMHC.

Preserved Wood Foundations: an evaluation

Preserved wood foundations (PWF's) have been built in Canada for almost 30 years but in Alberta only since the mid-1970's when they were approved by code authorities.

While PWF use is widespread, there has been little monitoring done to evaluate their performance. Recently, the Alberta Ministry of Municipal Affairs sponsored a project to evaluate the performance of preserved wood foundations in Alberta and to recommend any changes to current standards if appropriate.

The project involved:
- a computer search of 7 construction and forestry databases,
- a literature review,
- a survey involving 14 industry representatives,
- site inspection and material sampling at 32 test homes,
- a questionnaire sent to 225 owners

Site Inspections

32 site inspections involved a detailed review of the residences, discussions with the owners, plus the collection of soil and 25 wood samples from each PWF.

The soil and wood samples were collected and analyzed for moisture content. The key issues raised in the study concerned the wood and soil moisture content as they were affected by construction practices; these in turn affected the PWF basement. It was noted that in general the construction quality was acceptable but there were major deficiencies in selection and placement of backfill materials and in surface water management.

Despite these shortcomings, the average moisture level in the preserved wood walls below 15%. This is significant because "wet service conditions" design criteria must be used when wood moisture content reaches 15%. While these are more restrictive than the conventional "dry-service condition" wet-service wood design adds to the cost of any PWF.

The study noted that PWF basements perform exceptionally well in spite of the poor water management found in the cases investigated. This suggests that some of the design requirements may be too strict. The study also concluded that where climatic and soil conditions are similar to those found in the test area, it may be possible to eliminate the use of preservative treated studs in favour of conventional lumber.

Literature review

A review of the literature found that a number of studies discussed and evaluated the rock drainage layer under PWF's. The consensus was that this was a very effective drainage technique and noted that the system could be installed in wet site conditions.

A comparison of prevailing American and Canadian standards indicates that in general, Canadian PWF's are built to higher and more demanding standards than those in the U.S.A. For example, in Canada stainless steel fasteners are required below grade, but these are not required in the United States. Canadian standards require more restrictive stress modification factors and base their design formulas on wet service conditions versus the American assumption of dry service conditions.

Moisture

The primary focus of PWF's will continue to be the exclusion of ground water from the basement.

The literature was uniformly supportive for the PWF construction approach. It was noted that preservatives were effective in protecting wood from decay in even the most severe fungal and termite infested environments. Properly constructed wood basements were dry, warm and provided an excellent environment.

Nearly two thirds of the homeowners installed and maintained proper eavesthroughs and downspouts as a means of surface water management, but nearly 60% of the lots were improperly graded and had sites which sloped toward the home. While it was impossible to inspect the exterior dampproofing because of landscaping, it was noted that despite the generally poor grading only three of the homes had experienced any form of basement leakage. In fact, the sump pumps in seven of the homes had never been active.

Preservatives

Two respondents raised points about the use of wood preservatives. One suggested that the level of treatment be reviewed to determine whether lower levels of chemical penetration could be allowed as this would significantly lower the material cost of a PWF. Another was concerned about the toxicity of the chemicals used and suggested that those handling preserved wood should be advised to wear a mask and gloves.

Construction Practices

The most critical concern addressed the improper application of the standard. Contractors and designers often approve the use of improper backfill materials or procedures. The current CSA standard was being used as a construction handbook without proper consideration given as to how the specifications, conditions or underlying theory contained in that standard might apply to unique designs or site-specific problems.

No galvanized framing anchors or straps showed any sign of deterioration, thus indicating that they were performing well. However, it was also noted that there had been a lapse in construction quality in some homes. Six of 32 homes did not have any insulation in the joist box spaces at the main floor. More importantly, 24 of 32 homes or 75% did not have an effective air/vapour barrier on the basement PWF walls.

The following general observations were made:

- occupants of properly constructed PWF's are satisfied with their homes;
- properly constructed PWF's perform very well and provide dry, warm and
- comfortable living space;
- PWF's are perceived as easy to build;
- PWF's don't result in any insurance surcharge,
- owners of PWF's consider them equal to or better than other types of basement construction with which they have experience.

When topsoil and organic matter are mixed with the granular backfill, there is a significant increase in normal moisture content, (in one case from 8% to 22%). In cases where the native soil/sands have high permeability, the resulting moisture levels are very low (5% and 8%).

It is suggested that where the native soil has a high permeability, it is not necessary to install a 6" granular drainage layer below the PWF construction. Further, it was noted that most basements have adequate ground moisture control without the mandated drainage layer; it is recommended that a combined backfill of stiff to medium clay over a granular material would be acceptable. There are however two caveats:

(i) the combined backfill must not result in forces which exceed allowable stress and deflection limits in the studs and plywood and

(ii) the equivalent fluid pressures used for the clay in the design calculations must equal 75%, which places limitations on the type of clay that can be used.

It was noted that only 3% of the basements had been backfilled or graded in conformance with prevailing code requirements. The study recommends that the building code be clarified to emphasize that the authority having jurisdiction is responsible for the inspection and approval of these construction practices.

Wood Samples

Wood samples were taken from different locations in the foundations of each of the inspected homes, and were laboratory tested to determine their moisture content. (The samples were taken during the last week of July and August 1987).

One sample was taken from each of the following locations:
- PWF bottom plate (it was not possible to secure samples from the footing plates),
- top plate,
- tie plate,
- bottom plate of an interior partition, and
- 3" above bottom plate in interior partition.

Samples were not obtained from the exterior plywood sheathing of the basements as homeowners were unwilling to have any punctures made in their primary moisture barrier, but electronic moisture meter readings were made of the PWF plywood at each location where wood samples were taken.

The analysis of the samples showed the following findings:
- Moisture contents were always highest when the site sloped towards the house (i.e. negative drainage)
- The studs had a higher moisture content towards the outside face.
- No stud had a moisture content above 30% (which is generally accepted as the point at which rot can happen.)
- The Base plates had moisture levels above 30%.
- Moisture content of studs decreases with distance above the base plate.
- Even under adverse negative drainage conditions, the mean stud moisture content did not exceed 15% at any spot other than the point 3" above the base plate.

Because moisture contents did not exceed 30% or even 15% more than 3" over the plate, it is suggested that PWF studs in climatic and soil conditions similar to that of the test area need not be treated with preservative.

In addition, the study suggests that dry service conditions can be used in calculating structural performance as studs only had high (15%+) readings in the lower 3".

The inclusion of a dampproofing material between the base plate and the studs should eliminate the wicking effect from the moist plate into the essentially dry stud.

It would appear that careful material selection and the use of site specific design standards can result in significant savings. These can be as much as $1,743.00 for a modest house.

The findings and recommendations made by this study are limited in application to those areas with soil and climatic conditions similar to the Edmonton area. However, the conclusions should be seriously considered for their potential impact on PWF installations in other areas.

This is a summary of: "An Evaluation of Preserved Wood Foundations in Alberta", prepared by T.N. Brown, P. Eng with funding provided by the Innovative Housing Grants Program, Alberta Municipal Affairs.

HOT 2000 (version 5.06): review

Richard Kadulski

Some things improve over time. The HOT2000 computer program (originally known as HOTCAN) is one of these. It was developed for use by the R-2000 program to evaluate compliance with energy consumption targets, as well as to offer a design tool for designers and builders to assess alternate construction options.

HOT2000 has been continuously refined, and now is a much more sophisticated tool than the original HOTCAN. It offers a sophisticated diagnostic tool that is relatively easy to use, but some may think that it's too elaborate. There are other programs available - but they are either very elaborate and much more complex or they are more limited in what they offer. Monitoring of R-2000 houses has demonstrated the accuracy of HOT2000.

HOT2000
Version 5.06
Energy, Mines & Resources CANADA
Nov 30, 1988

1 — House Edit
2 — Weather handler
3 — Economic comparison
4 — Home Enrolment
5 — Spool Reports
6 — Re-install program
0 — Quit

ENTER YOUR CHOICE:

You don't really need a computer and a program such as HOT2000 to calculate house heat loss - but it takes a lot of time, while the computer can do the number crunching in a few seconds.

What does HOT 2000 do?

It performs a detailed heat loss/heat gain analysis, identifying the energy losses through the various elements of a building. By altering any element, the importance of each can be determined, thus making it easy to select the most cost effective options. It calculates the design heat loss, as well as solar and internal heat gains.

It is relatively easy to use, but it does take some effort to learn to use it properly to be useful (*remember the GIGO principle of computing: garbage in = garbage out*). To get accurate results requires accurate inputs. This is not the type of program you sit down at, plug in 3 or 4 numbers, and get an answer.

For the R-2000 program in B.C. I developed and ran hands-on workshops on the use of HOT2000. In 2½-3 days proper take off procedures are reviewed, and an examination made of the inputs and outputs. It is not necessary to take a course in order to use HOT-2000 but it reduces the learning time (something we forget about when we plunge into the joys of new technology).

HOT 2000 (v5.06) Features

* Menu selection of program options
* weather data for 75 Canadian locations (US version 150 US sites)
* user defined weather files can be set up
* input in Imperial, U.S. or metric units (automatic conversion possible)
* models HRV efficiencies at 0°C and -25°C to derive an average overall efficiency.
* models and calculates ventilation rates based on current R-2000 criteria or user defined rates
* Models 3 foundation types: Slab-on-grade, shallow or full depth basements taking into account insulation placement and wet, dry or permafrost soil conditions.
* models open, closed or vented crawl spaces
* calculates monthly wind and temperature induced infiltration rates
* calculates the design heat loss for the January 2½% design temperature (used to size space heating systems)
* simulates primary and secondary domestic water heating systems (including solar)
* models a range of heating system and fuel types
* can model up to 10 different entries for each building element with user defined values
* mechanical systems can be input using default values for common types or user defined entries.
* inputs have calculator function available (i.e. you can enter an area as 20x30 rather than 600 sq.ft.)
* entries are limited to realistic bounds (i.e. you can't enter a window with no glazing or 24)

Preparation of input data involves doing a manual plan take-off to calculate component areas. For a typical house, doing the take-off itself can take anywhere from 1-3 hours or more depending on the complexity of the house.

All input values are user defined (no defaults are provided except for efficiency of heating and hot water systems) so user discretion is needed in deciding whose numbers are going to be used. The standard practice of the R-2000 program is to use nominal R values of the insulation, but the user can choose what he wishes.

Entry of data is quick. Once entered, editing of any specific component (to correct a typing error or to make changes) is quick. Duplicate files for editing are created quickly when needed.

HOT2000 makes it easy to do quick analyses of alternate materials, configurations and insulation levels. Even if a take-off was done less than accurately, comparative runs will provide a fair basis of comparison between different materials.

The documentation that comes with the program is well done and fairly comprehensive. A User Manual answers most questions that one may have. It outlines the options available and what the R-2000 Home Program requires or uses as assumptions.

Also included is a Reference Manual that explains the calculation procedures and provides the formulas used by the program.

HOT2000 has a couple of extra modules that are of interest. The economic analysis provides a quick calculation of P.I.T.E. payments (principal, interest, taxes and energy). It will derive simple and discounted payback periods, years to positive cash flow, return on investment and net present value of any incremental costs. The economic analysis is done on 2 houses. This makes it possible to prepare an analysis where the base case may be the 'standard' house and the second house incorporates the options and upgrades proposal.

Users of earlier versions of HOT-2000 will appreciate the changes made in the latest version (5.06). The calculations are done much quicker than previously. On the IBM-PC or XT or compatibles it was a slow calculation; you went for coffee while the computer did its thing. On an AT it was much quicker, but you still waited a few seconds. Now, the number crunching is done instantaneously. This means that if you are looking at various options, you can get results on screen quickly. MacIntosh users can now use HOT2000 as a Mac version has been prepared.

Another significant improvement is that if you are doing several files, or want to have several print-outs, you can spool reports. Batch printing of up to 21 reports is now available, so you are no longer at the mercy of the printer speed, but can save up the printing of reports to the end of a work session, and have them all run off at the same time.

The program provides a detailed output, which includes all inputs and calculations done, as well as much additional material on mechanical systems. It has much more information than is usually needed (a full printout typically is 6-8 pages). In fact, the full report output is often confusing. The new version gives the option to choose several shortened out puts.

Anyone who uses an earlier version of HOT2000 on a regular basis should seriously consider upgrading to this latest version. The improved speed, and printer options alone will more than repay themselves in no time.

Anyone who is not now using a tool for calculations of house performance, but is actively engaged in design and construction should consider using it. If you have occasion to only use it 3 or 4 times per year, it just may be cost effective to have a consultant do the work for you.

HOT 2000 is available for IBM or MacIntosh. The IBM version requires a minimum system memory of 512k bytes, MS-DOS (2.1, 3.0 or later); the MacIntosh version requires a minimum system memory of 512k bytes, version 6.0 of the Finder. Any standard printer can be used.

Price: $ 120.00 for Canadian version; $ 150.00 for the U.S. version.

For more information, contact:
HOT 2000 Sales
Canadian Home Builders Association
Ste. 702, 200 Elgin St.,
Ottawa, Ont. K2P 1L5

Gas Fireplace Alert

Due to major promotion by B.C. utilities over the last few years gas fireplaces are now the preferred option for new and retrofit applications.

A wide range of options is available, from packaged gas logs for use in conversions of conventional masonry fireplaces, to fireplace inserts (modified versions of prefab zero clearance fireplaces) to gas fireplace heater units, designed as space heaters.

For health and safety (to reduce the likelihood of flue gas spillage into living spaces and to promote use of higher efficiency units) the R-2000 Program and B.C.'s Quality Plus program insist on direct vent (sealed combustion) or induced draft units if gas fireplaces are used.

Direct vent gas fireplaces require no flues; power vented fireplaces can be located on an inside wall and use a fan vented to outside through a side wall.

To offer sealed combustion models, some manufacturers have adapted their zero clearance woodburning fireplaces to gas by sealing tempered glass panels over the opening (the units have been certified). However, it has become evident that tempered glass for use in direct vent fireplaces is not adequate for all models.

The B.C. Gas Safety Branch has received reports of glass shattering on direct vent fireplaces with tempered glass. In the interest of safety and until the use of tempered glass can be proven safe for specific installations, they require that all direct vent gas fireplaces installed in the province of British Columbia be of a design that will prevent the expulsion of glass into the room should the glass that provides the seal shatter. In some cases this may be a screen in front of the glass.

Units that use ceramic glass are not affected by this problem.

What seems to be happening in those units affected is that the glass bows in when as it heats up; when the unit cools down, the stress on the glass is enough to shatter the glass. Perhaps it may be that the heat output is too high for the materials. An open fireplace has enough air flow that the heat is removed before glass temperatures can build up.

On November 14, 1989 the B.C. Gas Safety Branch issued an order that requires all suppliers to immediately provide a list of all direct vented fireplace installations using tempered glass and to establish a timetable for their replacement or change in design. In addition, the suppliers must advise the owners of direct vent gas fireplaces of the situation and provide instructions for the safe operation of the fireplace.

A manufacturer's list has not been assembled. We understand that some models affected include those manufactured by Heatilator, Superior and Heat & Glow. In general, European made sealed combustion units use ceramic glass so they are not affected.

A Question of Standards

A question that must be asked is what do the standards call for when a fireplace unit is certified? What is tested? How safe are certified units? Can the standards deal with innovation and changes to designs that happen quickly? When direct vent units showed up, were existing standards adequate to deal with the concerns involved with direct vent appliances? Manufacturers quote efficiency ratings (and imply the ratings have been certified) but what tests (if any) are done to determine efficiency?

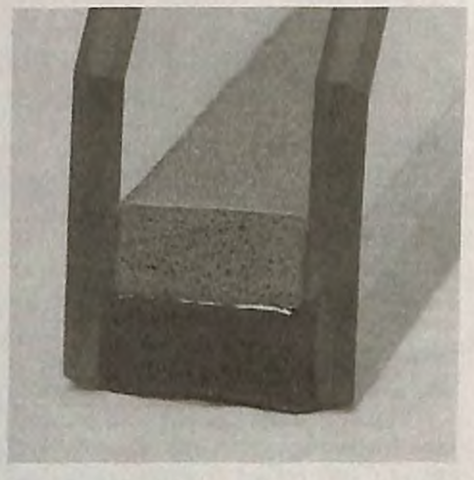
Do certification tests consider flue gas temperatures at the exhaust point? It has been observed that the temperature of the flue gases from direct vent appliances can be dangerously high. In some cases they can be well in excess of 500°F.

Direct vent terminations in B.C. now *must* meet the following criteria:

Minimum clearance from the ground to the vent termination or any area that is accessible without protection must be 7'. (Any protection covering the vent terminations must not restrict the operation of the vent.)

Vents installed adjacent to combustible material must meet manufacturers' specifications. Vent terminations must not warp or damage exterior wall finish. This especially applies to vinyl siding, as there have been reports of vinyl siding melting due to the high temperatures of the flue gasses.

Super-Spacer™



Low-e coatings and argon gas fill are features of insulating-glass technology that are proven energy savers. They have become popular over the past five years, but their true potential has not yet been realized due to heat loss through the metal glass spacers. For a conventional wood-framed, residential sized window, this amounts to about a third of potential energy savings.

Edgetech I.G. Ltd. has produced a new spacer called **Super Spacer™**. It's a flexible spacer made from UV resistant silicone foam that incorporates a desiccant fill material. The performance of the spacer's foam insulation material allows the potential of super-window technology to be fully realized. With the perimeter condensation reduced low-e performance is available from edge-to-edge.

The **Super Spacer™** has a pressure sensitive adhesive that structurally bonds the spacer to glazing. The best edge-seal performance is achieved when the spacer is backed by hot-melt butyl sealant. This reverse double seal design minimizes moisture vapour and gas transmission with a vapour barrier film providing secondary protection. The flexible foam construction reduces glass and sealant stress, so it should have a longer life span.

The spacer design takes into account manufacturing and assembly considerations. For the producer this simple, labour saving strip eliminates the need for desiccant filling and other time consuming tasks. Assembly procedures

are made simple enough to be accomplished in small glass shops with minimum equipment investment.

For Information Contact:
Edgetech I.G. Ltd.
39 Vaughan St., Ottawa, ON K1M 1W9
Tel: (613) 749-0624

CMHC Housing Awards 1990

CMHC's second biennial Housing Awards competition is focusing on Housing for Young Families.

All professionals involved in housing, no matter what their speciality, are eligible to enter. The competition recognizes excellence in five categories that cover the spectrum of activities leading to the production and provision of housing in Canada, from financing and technology to planning and design to regulation and management.

Individuals, interest groups, non-profits, co-operatives, manufacturers, provincial and municipal governments and agencies are eligible. The key requirement is that they have improved access to good, affordable housing.

Deadline for entries is 15 March 1990.

For more details contact:
The Manager, CMHC Housing Awards
CMHC Research Division
682 Montreal Road
Ottawa, Ont K1A 0P7

Manitoba Radon Program

Winnipeg has among the highest radon levels in Canada. The Manitoba Government has responded with **RAP** (an inter-departmental Radon Action Plan). It is a program of research, information, and building retrofits.

Components in the program include:
- *A survey to establish the extent of radon in buildings outside of Winnipeg.*
- *Schools in Manitoba will be surveyed.*
- *Research to evaluate and demonstrate radon control methods in homes.*
- *The Ministry of Environment will develop a training program for radon contractors and the Ministry of Labour will develop a certification program.*
- *Manitoba Environment will do random tests of radon contractors to maintain quality assurance.*
- *Manitoba Consumer and Corporate Affairs will handle public complaints.*
- *Radon related items will be added to the Manitoba Building Code in 1990.*
- *Information will be made available through brochures, newsletter, and speakers bureau.*
- *Manitoba Energy and Mines Info Centre will be a radon information clearing house.*

A 40 page booklet **Radon: an Interim Guide for Manitoba Homeowners** has been prepared, adapted from literature produced by the US Environmental Protection Agency.

For more information contact: Manitoba Energy and Mines Info Centre,
555 - 330 Graham Ave., Winnipeg, MB R3C 9Z9
Tel: (204) 945-4154

Sticky Radon

An important feature of radon is that radon daughters are unstable charged particles that stick to nearby surfaces. This is taken advantage of in radon remedial work.

Research by Stephen Schery at New Mexico Institute of Mining and Technology found that material type, temperature and humidity have a bearing on how much radon plates out.

Radon is about 100 times more likely to bind to masonite, clay and some wood based building materials than to quartz sand, fired brick, cinder block or gypsum board. It was also noted that at higher moisture content or higher temperatures less radon adhered. A 10°F increase in temperature can reduce by half the sorption to some materials.

This suggests that design of radon barriers may have to take into account not just materials but also the average temperature and humidity conditions in which they will be used.

Efficent household appliances

Energy efficiency of new homes has been improved. We stress the building envelope but not household appliances, yet they also consume energy. For the utility appliances such as refrigerators are an important base load.

Appliance makers have been slow to change waiting for "market demand" to ask for product refinements (it is expensive to re-tool an assembly line). On the other hand the consumer has few options to influence the market (you can't buy a product that's not there).

In Canada the Energuide program requires that the average energy consumption be noted on a label fixed to the appliance. It is mandatory that the energy ratings must be registered with the federal government. Until recently, EMR published a list of appliances and their ratings. However, they are not policed, and it seems no one is certain just who is maintaining the registry. The last list published was several years ago.

When B.C. Hydro started to promote energy efficient refrigerators as part of Power Smart (the utility's demand side program), they could not get an updated Energuide list from EMR. They had to go directly to the manufacturers to put together a list.

The program offers an incentive of a $50.00 rebate on new refrigerators if they are in the top 15% of units in its category (volume & single or double door model).

Canadian manufacturers were outraged as at first most eligible models were imported units. It was pointed out that any unit that qualifies will be listed (in other words, "don't whine, just improve your product").

What about market response? Launched in June, by the end of November, 4200 rebates were given out. (Annual B.C. sales are about 50,000 units. The target for the second year is 15,000 rebates). The response prompted one manufacturer to make models just for B.C. (until they can increase production for the rest of Canada).

Manufacturers are crying the blues about the high cost of changes especially as they also have to eliminate the use of CFS's. But what have they been doing all these years? They've spent money on new product development (colours, trim changes), but how much on technical improvements to upgrade appliance performance?

The Canadian Electric Association, with the major utilities will help manufacturers upgrade their product lines, by assistinng with product research, development and marketing assistance to promote new products.

Kitchen Fans

Recent tests measured how good downdraft kitchen range exhausts are at removing cooking smells. They were done by the Department of Mechanical Engineering at the University of Minnesota. It turns out they may not be quite as efficient as they're supposed to be.

The tests measured air flow rate pressure drop, air velocity (measured and predicted), and flow visualization.

Downdraft units are good at removing cooking contaminants generated near the cooking surface. However, a unit with a raised rear vent is more effective at capturing steam from tall pans than units with vents level with the cooking surface.

The downdraft ranges generally have high airflow rates to overcome the thermal buoyancy (the tendency of hot gases to rise) of the hot cooking contaminants. However, air speeds near the vent overcomes the thermal buoyancy of the cooking contaminants and improves the capture of the contaminants. The lower air speeds away from the vent may not be high enough to capture the contaminants released there.

Effect of pan height on capture of steam with a downdraft fan, 300 cfm airflow

There is good capture of fog and steam contaminants released close to the cooking surface, in the area where the air velocity was high (the steam was released from a pan 2 3/4 inches high). For the side-vent unit with two fan speeds the capture was not as effective on the low speed as on the high speed. The capture of steam from a 5 inches high pan was poor for both units since the steam leaves the pan at a distance from the vent, where the air speed is low and cannot overcome the thermal buoyancy of the steam.

The measured airflow rates of the three downdraft systems were consistent with the rated airflows. The units are not affected drastically by changes in the exhaust ductwork.

Steam capture by an overhead hood, fan airflow rate 280 cfm

When powerful kitchen exhaust systems are used alone or with other exhaust appliances, depressurization of the house is a concern. It is a important to determine if a kitchen exhaust system will cause backdrafting.

Both simple and technical tests can be used to determine if there is a depressurization problem. A temporary solution is to open a window whenever the kitchen range exhaust system is turned on. Two code approved methods of providing combustion air, passive air inlets and a duct to the cold air return plenum of the furnace, are not a good way for bringing in outside air for the exhaust appliances.

A better method would be the use of a supply fan to force air into the house in order to prevent depressurization when the kitchen range exhaust system is used.

Care must be taken when providing outdoor air using passive air inlets and ducts to the cold air return of the furnace as the passive air inlet has not been found to be reliable. The opening or duct needed when experiencing the highest levels of depressurization can be quite large (as much as 14 inches in diameter). Usually, the air inlets are undersized. If the air in not tempered the air inlet may be blocked off by the occupant.

Under some weather conditions passive air inlets become outlets. With no wind, the passive air inlet may work as designed. If the inlet is on the windward side of the house, more air will enter the house than the inlet was designed to let in. When the inlet is on the leeward side of the house, it may allow air to be drawn out of the house. The leeward side of a house (on the outside) can be depressurized by 7 Pascals (0.03 in wg) in a 20-mph wind.

For information:
Cold Climate Housing Center
203 Kaufert Laboratory, 2004 Folwell Avenue, University of Minnesota
St. Paul, Minnesota 55108

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